CLAIMS

What is claimed is:

1. An extendable wing system for a fluid-born body, comprising:

a forward wing extending from a forward wing root to a forward wing tip;

an aft wing extending from an aft wing root to an aft wing tip;

the forward wing and the aft wing pivotably coupled together at a location outward of the forward wing root and the aft wing root; and

a linkage mechanism translationally and rotationally coupled to the forward wing root and the aft wing root and configured to effect extension of the forward wing and the aft wing from a stowed position to a deployed position by translation of the forward wing root and the aft wing root along a path.

2. The extendable wing system of claim 1, further comprising an actuating mechanism operatively coupled to the linkage mechanism to drive translation of at least one wing root, and rotation of the wing roots follows translation of the wing roots.

3. The extendable wing system of claim 2, wherein the actuating mechanism is operatively coupled to the linkage mechanism to drive the aft wing root.

4. The extendable wing system of claim 1, wherein the linkage mechanism is disposed to provide a determined ratio of translation of one wing root relative to translation of the other wing root.

5. The extendable wing system of claim 1, wherein the linkage mechanism further comprises a linear rail, the forward wing root

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and the aft wing root each mounted to a block disposed for travel along the rail.

6. The extendable wing system of claim 5, wherein the linkage mechanism further comprises a pivoting mechanism mounted on each block, the forward wing root and the aft wing root mounted via the pivoting mechanism to the block.

7. The extendable wing system of claim 5, wherein a pivot point of the aft wing root is laterally displaced with respect to the rail from a pivot point of the forward wing root.

8. The extendable wing system of claim 5, further comprising an actuating mechanism operative to actuate translation of the blocks.

9. The extendable wing system of claim 5, further comprising an actuating mechanism operative to actuate translation of one of the blocks, and the other of the blocks is coupled to the one of the blocks for translation therewith.

10. The extendable wing system of claim 5 wherein the linkage mechanism further comprises a pulley system coupling the forward wing root and the aft wing root.

11. The extendable wing system of claim 1, further comprising an actuator element on or within at least one of the forward wing and the aft wing, the actuator element operative to deform the associated wing in response to a control signal.

12. The extendable wing system of claim 11, wherein the actuator element comprises a piezoelectric element.

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13. The extendable wing system of claim 11, wherein the actuator element comprises a shape-memory alloy, a ferroelectric material, or a ferromagnetic material.

14. The extendable wing system of claim 11, wherein the actuator element is disposed on a pressure face of the associated wing.

15. The extendable wing system of claim 11, wherein the actuator element is disposed to generate a torsional deformation of the associated wing.

16. The extendable wing system of claim 11, further comprising a plurality of actuator elements distributed along at least a portion of one of the wings.

17. The extendable wing system of claim 11, wherein the actuator element is located at a discrete location along one of the wings.

18. The extendable wing system of claim 11, wherein the actuator element is disposed adjacent a trailing edge at the wing root of one of the wings.

19. The extendable wing system of claim 18, wherein the actuator element comprises a piezoelectric element.

20. The extendable wing system of claim 1, wherein the forward wing and the aft wing comprise composite pultrusions.

21. The extendable wing system of claim 1, wherein the forward wing and the aft wing comprise fiber-reinforced, resin matrix composites having at least a portion of fibers extending continuously in a spanwise direction between the wing root and the wing tip.

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22. The extendable wing system of claim 21, wherein a further portion of the fibers extends at an acute angle to the spanwise direction.

23. The extendable wing system of claim 22, wherein the further portion of the fibers extends at generally ±45° to the spanwise direction.

24. The extendable wing system of claim 21, further comprising a core within the portion of the fibers.

25. The extendable wing system of claim 24, wherein the core comprises fibers or a foam material.

26. The extendable wing system of claim 21, wherein the forward wing and the aft wing are hollow.

27. The extendable wing system of claim 1, wherein the forward wing and the aft wing are comprised of metal.

28. The extendable wing system of claim 1, wherein the forward wing and the aft wing each have an airfoil profile in cross-section.

29. The extendable wing system of claim 1, wherein at least one of the forward wing and the aft wing has a spanwise twist distribution.

30. An air-born body comprising:

a fuselage;

a first extendable wing system and a second extendable wing system according to claim 1, the first and second extendable wing

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systems mounted to the fuselage to extend on opposite sides of the fuselage in the deployed position and to store against the fuselage in the stowed position.

31. The air-born body of claim 30, wherein in the stowed position, the forward wing roots of the first and second wing systems are disposed closer to a nose of the fuselage than in the deployed position.

32. The air-born body of claim 30, wherein the forward wing roots of the first and second wing systems are disposed further aft in the deployed position than in the stowed position.

33. The air-born body of claim 30, wherein a center of pressure of each of the first and second wing systems is disposed further aft than a center of gravity of the air-born body with the first and second wing systems in the deployed position.

34. The air-born body of claim 30, wherein a center of pressure of at least one of the first and second wing systems is disposed further aft than a center of gravity of the air-born body with the first and second wing systems in the deployed position.

35. The air-born body of claim 30, wherein a center of pressure of each of the first and second wing systems is disposed further forward than a center of gravity of the air-born body with the first and second wing systems in the deployed position.

36. The air-born body of claim 30, wherein a center of pressure of at least one of the first and second wing systems is disposed further forward than a center of gravity of the air-born body with the first and second wing systems in the deployed position.

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37. The air-born body of claim 30, wherein the forward wing of the first wing system and the forward wing of the second wing system are coupled for simultaneously translation by the linkage system.

38. The air-born body of claim 30, wherein the aft wing of the first wing system and the aft wing of the second wing system are coupled for simultaneously translation by the linkage system.

39. The air-born body of claim 30, wherein the forward wing root of the first wing system and the forward wing root of the second wing system are coupled by the linkage mechanism for simultaneous motion.

40. The air-born body of claim 30, wherein the rear wing root of the first wing system and the rear wing root of the second wing system are coupled by the linkage mechanism for simultaneous motion.

41. The air-born body of claim 30, wherein the forward wing root of the first wing system and the forward wing root of the second wing system are coupled by the linkage mechanism for simultaneous motion; and

the rear wing root of the first wing system and the rear wing root of the second wing system are coupled by the linkage mechanism for simultaneous motion.

42. The air-born body of claim 30, wherein the forward wing root of the first wing system and the forward wing root of the second wing system are independently coupled to the linkage mechanism.

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43. The air-born body of claim 30, wherein the rear wing root of the first wing system and the rear wing root of the second wing system are independently coupled to the linkage mechanism.

44. The air-born body of claim 30, wherein the forward wing root of the first wing system and the forward wing root of the second wing system are independently coupled to the linkage mechanism; and

the rear wing root of the first wing system and the rear wing root of the second wing system are independently coupled to the linkage mechanism.

45. A method of deploying extendable wing systems on an air-born body, comprising:

providing an air-born body comprising:

a fuselage;

a first extendable wing system and a second extendable wing system according to claim 1, the first and second extendable wing systems mounted to the fuselage to extend on opposite sides of the fuselage in the deployed position and to store against the fuselage in the stowed position; and

during flight, extending the first and second extendable wing systems from the stowed position to the deployed position, the forward wing root and the aft wing root of each of the first and second extendable wing systems translating during deployment.

46. The method of claim 45, wherein during deployment, the forward wing roots translate aft.

47. The method of claim 45, wherein during deployment, the forward wing roots translate forward.

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48. The method of claim 45 wherein during deployment, the first and second wing systems are extended until a center of pressure of each wing system is located aft of a center of gravity of the air-born body.

49. The method of claim 45, wherein the first and second wing systems are moved until a center of pressure of each wing system is located forward of a center of gravity of the air-born body.

50. A method of providing flight control for an air-born body, comprising:

providing an air-born body, comprising:

a fuselage;

a first extendable wing system and a second extendable wing system according to claim 1, the first and second extendable wing systems mounted to the fuselage to extend on opposite sides of the fuselage in the deployed position and to store against the fuselage in the stowed position; and

moving at least one of the first extendable wing system and the second extendable wing system to an intermediate position to control flight of the air-born body when air born.

51. The method of claim 50, further comprising retracting at least one extendable wing system relative to the other extendable wing system to effect a net rolling moment.

52. The method of claim 50, further comprising retracting the first and second extendable wing systems simultaneously to effect a nose down pitching moment.

53. The method of claim 50, further comprising moving the first and second wing systems symmetrically to effect motion of the air-born body.

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54. An air-born body comprising:

a fuselage;

a right extendable wing extending from a right wing root to a wing tip, mounted to a right side of the fuselage;

a left extendable wing extending from a left wing root to a wing tip, mounted to a left side of the fuselage; and

a linkage mechanism translationally and rotationally coupled to the right wing root of the right wing and the left wing root of the left wing and configured to effect extension of the right wing and the left wing from a stowed position against the fuselage to a deployed position by translation of the right wing root and the left wing root along a path.

55. The air-born body of claim 54, further comprising an actuating mechanism operatively coupled to the linkage mechanism to drive translation and rotation of the wing roots.

56. The air-born body of claim 54, wherein the linkage mechanism further comprises a rail, the wing roots each disposed for travel along the rail.

57. The air-born body of claim 54, wherein the linkage mechanism comprises a right rail and a left rail, the right wing root disposed for travel along the right rail and the left wing root disposed for travel along the left rail.

58. The air-born body of claim 54, further comprising an actuator element on or within the right and left wings operative to deform the associated wing in response to a control signal.

59. The air-born body of claim 57, wherein the actuator element comprises a piezoelectric element.

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60. The extendable wing system of claim 1, wherein the linkage mechanism is configured to effect translation of the forward wing root and the aft wing root along a linear path.

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